MTM

Journal of Methods Time Measurement

In This Issue . . .

A Detailed Physiological Difficulty Analysis of Manual Work

MTM Is No One-shot Panacea, But It Can Cut Factory Costs and Step-Up Your Production

History Development and Fundamentals

U.S. Navy Depot Warehousing

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The Journal of Methods Time Measurement

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MTM

MTM ASSOCIATION FOR STANDARDS AND RESEARCH

The Journal of Methods-Time Measurement is dedicated to the technical aspects, application development and general news items concerning the advancement of MTM.

The Journal encompasses the fields of endeavor that were formerly publicized in the MTM Newsletter and MTM Bulletin.

The technical section of the Journal is concerned chiefly with recent research developments both from the established research program at The University of Michigan, Ann Arbor, Michigan, and from somewhat smaller allied projects being conducted throughout the Association membership.

New applications of MTM as well as refinements of established applications are presented in the Application Section to illustrate specific approaches to management problems that can be solved through the use of Methods-Time Measurement.

Current events in the lives of persons associated with MTM are described in the general news section.

The Editorial Staff welcomes contributions for all three sections described.

MTM

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Editor's Note:

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MTM FEATURE

A DETAILED PHYSIOLOGICAL DIFFICULTY ANALYSIS OF MANUAL WORK*

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and

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It is interesting to direct one's attention to what makes one job more difficult to perform than another. The mental skills required for various types of work certainly vary widely in their range and complexity. The weight of objects lifted or moved, or the force or pressure required to overcome resistance, also greatly affect the degree of difficulty of work. In addition, job environment may tend to accentuate or aggravate other difficulties.

But even where these effects are not present, jobs still seem to vary greatly in their difficulty. That is, for a job that can be performed with a relatively simple set of instructions and no technical or vocational training, and which requires the handling of very light weight objects, there is still a range of physical difficulty involved. For example, a person quite capable of stacking small, light cartons might have difficulty threading a needle.

The source of this difficulty seems to stem from the degree of control that the body's motor activity must exhibit over the muscle actions principally of the eyes, arms, and fingers. The varying degree of control required usually exhibits itself during the terminal activities of motions, e.g., toward the end of arm reaches and moves, and normally toward the end of finger reaches and moves that occur during grasps and positions. It is the problem of identifying and systematizing this range of physical difficulty to which this paper addresses itself.

Since muscle activity results from stimulation of the individual muscle fibers by motor signals originating in the brain and spinal chord, all muscle action may be described in terms of this motor activity. Assuming no pathological complications (i.e., adequate strength and range of motion), the muscles are the slaves of the nervous system's motor stimuli. The speed or delicacy of limb motion is entirely a function of the type of motor control maintained over the body's musculature. Thus a person's ability to do work may be described in terms of his motor activity coordination, and the work in turn may be described in terms of its required motor control difficulty.

Proposed Structure of Difficulty Comparison. Research work done during the development of Methods Time Measurement indicates that at least three principal degrees of control difficulty are present in most reaches and moves, but probably no more than three except in extreme situations.** To this one may add another dimension of difficulty, the force or pressure required in the performance of the work.

Table I shows the manual motions used in the performance of work, listed by MTM symbol. For each element, the corresponding level or levels of difficulty (or degrees of difficulty) are indicated--Low, Medium, or High--and the approximate force or pressure required. The indicated level is that which would normally be encountered but it may vary under special conditions.

*Research financed by grants from the National Foundation and the Albert and Mary Lasker Foundation.
**KARGER & BAYHA, p. 318 (see Bibliography).

TABLE I

DEGREES OF CONTROL DIFFICULTY

MTM Element	Fingers and Hand				Arm and Shoulders			
	Low	Medium	High	Force or Pressure	Low	Medium	High	Force or Pressure
R-A	x				x			
R-B		x				x		
R-C			x				x	
R-D			x				x	
R-E	x				x			
M-A	x			0-45	x			0-45
M-B		x		0-45		x		0-45
M-C			x	0-45			x	0-45
T-S(1)				0-2		x		0-2
T-M				2-10		x		2-10
T-L				10-35			x	10-35
AP1(2)	xx	xx		45		x		45
AP2	x			30	x			30
AP3	x			15	x			15
G1A(3)	x							
G1B		x	x					
G1C1	x	xx						
G1C2	x	xx	x					
G1C3	x	xx	xx					
G2	xx	x						
G3	xx							
G4A	x		x					
G4B		x	xxx					
G4C	x	xx	xxx					
G5								
P1SE(4)			xx					
P1SD	xx	x	xx					
P1SSE			xxx					
P1SSD	xx	x	xxx					
P1NSE			xxx					
P1NSD	xx	x	xxx					
P2SE	x		xx	30	x			30

Notes:

(1) Turns assumed to require terminal accuracy commensurate with a case B Move (medium), except the T-L is considered comparable to a case C Move (high) because of the additional muscular difficulty introduced by the significantly higher force required. However, if required terminal accuracy is less than this, reduce the difficulty one level; if greater than this, increase the difficulty one level for T-S and T-M.

(2) Apply Pressure cases 2 and 3 assumed to consist of an MfA and the appropriate force or pressure, for both the fingers and the arm. AP1 assumed to be comparable to an MfB (because of the greater difficulty introduced by the higher force) for both the fingers and the arm, plus a G2 for the fingers.

(3) Grasps generally synthesized as per KARGER & BAYHA, op. cit., Table 2, p. 196 except that a G4A was assumed to consist of an M1C plus G1A. G1B has generally been observed to consist of an RfD plus a G5 plus an MfB.

(4) Positions generally synthesized as per KARGER & BAYHA, op. cit., Figure 5, p. 223. P1SE assumed to consist of MfC and M1C constituting align and engage. All turns assumed comparable to M-C.

TABLE I (Continued)

MTM Element	Fingers and Hand				Arm and Shoulder			
	Low	Medium	High	Force or Pressure	Low	Medium	High	Force or Pressure
P2SD	xxx	x	xx	30	x			30
P2SSE	x		xxx	30	x			30
P2SSD	xxx	x	xxx	30	x			30
P2NSE	x		xxx	30	x			30
P2NSD	xxx	x	xxx	30	x			30
P3SE	xxxx	xx	xx	30, 30, 30	xx	x		30, 30, 30
P3SD	xxxxxx	xxx	xx	30, 30, 30	xx	x		30, 30, 30
P3SSE	xxxx	xx	xxx	30, 30, 30	xx	x		30, 30, 30
P3SSD	xxxxxx	xxx	xxx	30, 30, 30	xx	x		30, 30, 30
P3NSE	xxxx	xx	xxx	30, 30, 30	xx	x		30, 30, 30
P3NSD	xxxxxx	xxx	xxx	30, 30, 30	xx	x		30, 30, 30
RL1	x							
RL2								
D1E(5)				1-5		x		1-5
D1D		x		1-5		x		1-5
D2E				10-15		x		10-15
D2D	x	x		10-15		x		10-15
D3E	x			30	x		x	30
D3D	xxxx	x		30	xx		x	30

(5) Disengages generally synthesized along the lines suggested by KARGER & BAYHA, op. cit., Table 2, p. 245, except that D3D assumed to consist of AP2 plus G2 plus AP2 plus M15.5Bm.

While the specific definitions for Low, Medium, and High levels of difficulty may vary slightly for the different elemental motions, it may be generally said that:

Low: An automatic motion, little more than a learned response, requiring no eye-hand coordination and only minimal motor control. It is accomplished by means of heavy reliance on subconscious kinesthetic and tactual senses. It is a ballistic motion with a simple acceleration caused by an effecting muscle group followed by a simple deceleration caused by an antagonistic muscle group. It is the most efficient type of movement of a body part since all of the muscle activity and timing has been programmed in advance by the brain. No hesitation occurs. Examples: Move case A and Reach case A.

Medium: A motion requiring some accuracy in its terminal activity (e.g., reaches and moves to within an inch or so of a given location) and usually requiring at least a low level of eye-hand coordination. It is also a ballistic motion, but with the added difficulty of some coordinated effector-antagonist muscle activity toward the end of the motion to arrive at an approximate location. Only the first portion of this movement may be preprogrammed by the brain; the terminal activity requires some sensory feedback (from visual and/or tactual senses) in order to make the few final adjustments in muscle activity necessary for final locating of the body part. These "few final adjustments" are observed as fumbles in the untrained person, but are generally not noticeable in the skilled worker so effectively are they damped out by the brain's cerebellum. Some small amount of hesitation occurs. Examples: Move case B and Reach case B.

High: A motion requiring much accuracy in its terminal activity (e.g., finger reaches or moves to within 1/4" or less and arm reaches or moves to within 1/2" or less) and requiring undistracted eye-hand coordination. If the motion covers some distance, it may start out as a ballistic motion, but the terminal activity is increasingly characterized by the simultaneous effector-antagonist muscle activity. Both muscle groups are activated, and it is the very fine balance of force differences between the effector muscles and the opposing antagonist

muscles which allows delicate motions of the body part.*** Much sensory feedback is needed. Depending on the accuracy requirements of the motion, hesitation of varying amounts normally occurs even for fully trained people. Examples: Move case C and Reach cases C and D.

Force is required to overcome the weight or resistance of a part or product being worked on, and Pressure is required to loosen or tighten parts or to activate some mechanism. Force is generally the application of effort resulting in motion of objects, while Pressure generally implies no significant movement of the objects involved. This differentiation between the two is not relatively important and the proposed system treats them alike.

The above definitions of difficulty are conveniently structured to coincide with the well-established MTM definitions. This was easy to do since the MTM cases were wisely chosen to represent significant physiological differences in motion difficulty. The MTM elements which consist of several elemental motions, such as Grasp and Position, have indicated for them in Table I the levels of difficulty of each of the elemental motions they contain. For example, a Regrasp (G2) usually contains two Low finger reaches (RfA) and a Medium finger move (MfB). An AP1 consists of a Medium difficulty motion plus a G2, for a total of two Low and two Medium motions. Also, a P3NSD is assumed to consist of a P1SE (2 High), two AP2's (2 Low each), one AP1, an exact Turn (1 High), and a G2 for a total of six Low, three Medium, and three High motions. These are indicated appropriately in Table I.

In an analysis of a job using the above procedure, each MTM element that occurred in a job would have its Table I values tallied in somewhat the following form (shown here for the assembly of an electric appliance plug):

Body Member	Level	Occurrences	Total	Percent
Arm and Shoulder (LEFT)	Low	𝍸 /	6	4%
	Medium	//	2	1%
	High	𝍸 /	6	4%
	Force or Pressure	15, 30, 15, 10	4	3%
Fingers and Hand (LEFT)	Low	𝍸 𝍸 𝍸 𝍸	20	13%
	Medium	𝍸 𝍸 ////	14	9%
	High	𝍸 𝍸 𝍸 ///	18	12%
	Force or Pressure	15, 30, 15, 10	4	3%
Fingers and Hand (RIGHT)	Low	𝍸 𝍸 𝍸 //	17	11%
	Medium	𝍸 𝍸 𝍸 𝍸 ////	24	16%
	High	𝍸 𝍸 𝍸 𝍸 𝍸 ////	29	19%
	Force or Pressure	30, 15, 15, 30	4	3%
Arm and Shoulder (RIGHT)	Low	///	3	2%
	Medium	///	3	2%
	High	𝍸 𝍸	10	7%
	Force or Pressure	30, 15, 15, 30	4	3%
			152	100%

***It is interesting that KARGER & BAYHA, op. cit., suggest using class 2 and 3 Positions for very accurate positioning even though no external force is needed. P2xx and P3xx contain Apply Pressures, and this is just what is happening; except that it is the effector muscle group pulling against the antagonist muscle group rather than the effectors exerting force on an external object.

The tally shows to the nearest percent what proportion of the total work load is performed by each body member and at what level of motor activity difficulty, and the proportion of these motions that require force or pressure.

The above results could be summarized in a more meaningful array of Difficulty Indices as follows:

DIFFICULTY INDEX SUMMARY

Body Member	Left		Right	
	Motions, % Low/Med./High	Force, Press. Min.(Ave.)Max.;%	Motions, % Low/Med./High	Force, Press. Min.(Ave.)Max.;%
Fingers and Hand	13/9/12	10(18)30;3%	11/16/19	15(23)30;3%
Arm and Shoulder	4/1/4	10(18)30;3%	2/2/7	15(23)30;3%

Thus a Motion Difficulty Index of 11/16/19 (i.e., Low/Medium/High) for the right hand, for example, indicates a more difficult than average (or medium) degree of control over motions. By comparison, a Motion Difficulty Index of 16/10/3 (from another job) would indicate a rather simple job, whereas an Index of 10/6/54 would indicate a very difficult and demanding job.

The differing symbolism of a 10(18)30;3% Index shows it to be a Force Difficulty Index, indicating an average force or pressure of 18 pounds required for only 3% of the elemental motions. An upper limit of 30 pounds is shown, which is the maximum force or pressure requirement of the job. Since the average of 18 is a little below the midpoint of the range (10 to 30), a distribution of forces skewed to the high side is indicated. In the above example, the Indices show that the number of motions requiring force are distributed evenly among the body members we are concerned with.

Thus a glance at the Difficulty Index Summary gives a reasonably good indication of the motor skill difficulty of a given job. Assisted by the well-structured definitions of MTM, it allows a simple, quantitative comparison of relative job difficulty.

It is recognized that the whole shoulder, arm, forearm, hand, and fingers form one complex kinetic chain in doing manual work. However, there are some advantages to an arbitrary separation of the total chain into meaningful sections. In this analysis, the arm and shoulder—involved principally in reaches and moves—was separated from motions of the fingers and hand—involved principally in work performed at any one part of the workplace or coincidentally with reaches and moves. This allows one to differentiate between, for example, sorting mail into bins and doing ink lettering on drawings; the former puts a premium on motor accuracy principally in the shoulder and arm while the latter puts a premium on motor accuracy in finger motions. The shoulder and arm muscles are the stronger of the two groups, while the finger muscles are the more precise of the two. Past experience and training will equip the effectors of these two groups with differing relative abilities. A further subgrouping of the shoulder-to-finger kinetic chain does not seem reasonable.

This separation concerns itself with the activities of the shoulder and arm and the activities of the fingers and hand rather than the location of the effecting muscles. Although most of the muscles that activate the hand are in the forearm, some even originating in the upper arm, motor activity of these muscles would come under the "fingers and hand" classification.

Preliminary Results. The value of this approach in our vocational evaluation of physically handicapped patients has been to assist in identifying the most demanding level of work, as indicated by the Indices, at which a person is able to perform satisfactorily (i.e., meet MTM normal times while using reasonably normal levels of effort).

The information thus developed is used by the handicapped person, with the assistance of a trained vocational counselor, in the determination of suitable job objectives and sources of employment. For these purposes, this approach has some considerable advantages in terms of the type and structure of the vocational evaluation. One such advantage is derived from the fact that comparable, constant, and knowable units, applicable to a wide range of occupations, is provided. This being the case, a relatively small number of tests can be constructed to cover a larger area of occupations. This eliminates the necessity for having a large (almost indefinite) number of discrete tests directly and specifically related to individual jobs.

The MTM approach, using physical activities as its base, provides descriptive material about clients which is understandable to medical personnel, vocational counselors, and industrial personnel workers. This, in effect, becomes a more generally understood language having work activity as its referent. In distinction to this is the more usual language of occupational medicine which consists of descriptions of general physical activity stated as percentages of "normal," a vague basis for judgments. The standardization of the time required for the performance of test work tasks makes possible an evaluation of the speed and quality of a client's work performance with established standards meaningful to industrial personnel and thus more usable in job placement efforts.

There are, of course, elements in ability to work other than capacity to perform necessary physical activities as described in the procedure herein suggested. For many clients of a rehabilitation center, the psychological tolerance for work activities is the major factor. The kind of evaluation being described here will allow for the assessment of some of these factors and will, in any case, be a valuable adjunct to other kinds of assessments (e.g., psychological tests, etc.). To engage in employment, a handicapped individual must demonstrate that he is physically capable of performing the necessary manual motions over a prolonged period of time. Thus, the testing can be extended to cover a time span which would allow for this demonstration (up to three or more weeks at near normal daily work schedules). This provides information about the fatigability and recoverability; data concerning ability to retain understanding of work sequences and processes or to recall those previously learned by varying the tasks; ability to maintain effort level in a routine, repetitive situation; and so forth. Rapid transfers from one kind of a job or series of operations or type of instruction to another can provide additional data regarding flexibility of adjustment, intelligence, motivation, etc., where all demands have actual industrial referents.

Research in this problem area will be continued to determine whether or not the above hypothesized approach gives a reasonable indication of the relative job difficulty of a wide range of semi-skilled and unskilled work. Refinements will undoubtedly occur, and perhaps additional variables will need to be recognized.

Preliminary results to date, based on a limited number of work tests, indicate that there is a significant correlation between motor difficulty of work as herein structured and performance during the work learning phase for everyone (i.e., it takes longer to learn work this system says it is more difficult) and even after learning for neuromuscularly involved persons. Based on a small sample of fully-gifted people, percentages of High Difficulty motions have a correlation coefficient of 0.891 with increasing percentages of time over Normal Time to complete a work test. A Student's test indicates this coefficient is significantly greater than zero at the 99% confidence level. A similar correlation was noted for mildly involved persons. For highly involved patients, psychological reaction to the nature of the different tests at varying levels of difficulty seemed to cause a lower correlation (but significantly greater than zero).

Thus, it seems that the proposed system differentiates between significantly different levels of job difficulty, and orders difficulty properly. Moreover, it quantitatively differentiates between observees (both fully-gifted and handicapped), with results quite similar to the results of qualitative clinical observations. It is becoming an increasingly helpful diagnostic tool.

Moreover, we see the procedure as having a more general applicability than herein illustrated. It should be helpful in the broad field of personnel testing wherein a detailed man-work matching is desired.

MTM NATIONAL I

The art of good plantmanship

MTM is no one-shot panacea, but it can cut factory costs and step up your production

Courtesy of W. B. Glassford–Plant Administration Magazine

Would you like to have accurate labor costs on a garment prior to going into production? Cut your labor costs 20% and slash operator training time? Have an accurate, inexpensive method of establishing incentives or piece work rates? And do all this with a tool that will enable you to accurately compare your existing equipment with newer types now on the market?

Then you should take a good look at Methods-Time Measurement.

It's no one-shot panacea designed to solve all your problems at once. But used properly, it can bring you the above results, regardless of your type of operation.

Sounds too good to be true? Maybe, but the record speaks for itself. Methods-Time Measurement (MTM for short) has only been widely available for a little over ten years, yet more than 1,000 Canadians already have been trained in the technique.

It is being applied in virtually every type of industry, from heavy industrial construction to hand painting of china. MTM has been used successfully to analyze and measure virtually every operation in the needle trade.

One American trouser and slack manufacturer says "By some strange miracle, MTM seems designed especially for sewing operations." Other plants report equally satisfactory results in everything from revising departmental layouts to evaluating new equipment.

Analyzed virtually every motion

MTM is a system based on the time required to make any motion. By adding together the time required for all movements in a job, the total time required to do the task is found.

The MTM system has analyzed virtually every motion involved in industrial operations, and assigned time values for each under specific conditions.

For example, if you pick up a pencil from your desk the time will vary according to the distance, the position of the pencil, the size of the pencil and whether there is anything between your hand and the pencil. Time values for this operation under the MTM system would vary according to each of these conditions.

Most previous attempts at work measurement in the needle trade have failed to solve one basic problem. Accurate cost data is needed before a garment goes into production. At the same time conventional time study techniques have to wait until an item is in production before measurement can start. Even manufacturers with relatively stable lines can do little more than estimate by comparing previous time studies to the new style's operations.

Consequently, it might be priced too low, too high, or even fail to be produced at all because of poor or inaccurate cost information.

Accurately estimating costs

MTM eliminates that problem. It provides a fast, accurate and economical method of determining your labor costs before a garment goes into production. At the same time it focuses attention on method improvements that help keep costs low.

Here's how it works.

Individual operations can be studied and analyzed motion by motion to come up with time standards for the job. This gives a highly accurate description of the method, and establishes the time required to do the job. But this is still a slow method, and quite costly.

To get maximum benefit from MTM in nearly all operations, it is most practical to use it to set up standard data or time formulas on operations or types of equipment. For example, the sewing formula shown on the second page of this article was developed using MTM for a Canadian toy manufacturer.

The operations in this plant involved using conventional machines for sewing dolls' dresses, clothes, etc., requiring varying degrees of accuracy, and rough sewing of such items as cloth doll bodies where very little accuracy is required.

With hundreds of new styles every year, accurate costs had to be developed before production started. Thousands of individual time studies were on file. But these were of no use in forecasting costs for the new items because of changes in style, methods, etc. The old method of taking time studies after the style was in production was out. It was too costly, both in actual costs of establishing standards and in faulty pricing through not having accurate standards before production started.

Developing a sewing formula

So it was decided to use MTM to develop a sewing formula for this work. One man spent several days observing the various operators at work. Then he sat down and built up detailed motion patterns for all common operations required in sewing. The entire job took less than

(continued)

THIS DATA . . .

makes up the heart of the Methods-Time Measurement system. It gives the time for performing virtually any motion required in industrial operations. By defining the exact motions required to do any job, the total time required for that job can be found from this table. Simple as the system looks, it can be misleading for those who don't have a thorough understanding of it. Variations in method which the casual observer would miss can cause great increases in the time required for the job. This is where MTM is most valuable — it forces attention on the elimination of unnecessary motions and experience has shown that savings of 20-25% on sewing operations are not uncommon.

TABLE I—REACH—R

Distance Moved Inches	Time TMU A	B	C or D	E	Hand In Motion A	B	CASE AND DESCRIPTION
¾ or less	2.0	2.0	2.0	2.0	1.6	1.6	A Reach to object in fixed location, or to object in other hand or on which other hand rests.
1	2.5	2.5	3.6	2.4	2.3	2.3	
2	4.0	4.0	5.9	3.8	3.5	2.7	
3	5.3	5.3	7.3	5.3	4.5	3.6	B Reach to single object in location which may vary slightly from cycle to cycle.
4	6.1	6.1	8.4	6.8	4.9	4.3	
5	6.5	7.8	9.4	7.4	5.3	5.0	
6	7.0	8.6	10.1	8.0	5.7	5.7	C Reach to object jumbled with other objects in a group so that search and select occur.
7	7.4	9.3	10.8	8.7	6.1	6.5	
8	7.8	10.1	11.5	9.3	6.5	7.2	
9	8.3	10.8	12.2	9.9	6.9	7.9	D Reach to a very small object or where accurate grasp is required.
10	8.7	11.5	12.9	10.5	7.3	8.6	
12	9.6	12.9	14.3	11.9	8.1	10.1	
14	10.5	14.4	15.8	13.0	8.9	11.5	E Reach to indefinite location to get hand in position for body balance or next motion or out of way.
16	11.4	15.8	17.2	14.2	9.7	12.9	
18	12.3	17.3	18.6	15.5	10.5	14.4	
20	13.1	18.8	19.9	16.7	11.3	15.8	
22	14.0	20.1	21.3	18.0	12.1	17.3	
24	14.9	21.6	22.7	19.2	12.9	18.7	
26	15.8	23.0	24.0	20.4	13.7	20.2	
28	16.6	24.5	25.4	21.7	14.5	21.7	
30	17.5	25.9	26.7	22.9	15.3	23.2	

TABLE II—MOVE—M

Distance Moved Inches	Time TMU A	B	C	Hand In Motion B	Wt. Allowance Wt. (lb.) Up to	Factor	Constant TMU	CASE AND DESCRIPTION
¾ or less	2.0	2.0	2.0	1.7	2.5	0	0	A Move object to other hand or against stop.
1	2.5	2.9	3.4	2.3				
2	3.6	4.6	4.9	3.3	7.5	1.06	2.2	
3	4.9	5.7	6.7	3.5				
4	6.1	6.9	8.0	4.3	12.5	1.11	3.9	
5	7.3	8.0	9.2	5.0				
6	8.1	8.9	10.0	5.7	17.5	1.17	5.6	B Move object to approximate or indefinite location.
7	8.9	9.7	10.8	6.5				
8	9.7	10.6	11.8	7.2	22.5	1.20	7.4	
9	10.5	11.5	12.7	7.9				
10	11.3	12.4	13.5	8.6	27.5	1.28	9.1	
12	12.9	14.1	15.4	10.0				
14	14.4	15.8	17.0	11.4	32.5	1.39	10.8	C Move object to exact location.
16	16.0	17.6	18.7	12.8				
18	17.6	19.3	20.4	14.2	37.5	1.39	12.5	
20	19.2	19.7	22.1	15.6				
22	20.8	19.7	23.8	17.0	42.5	1.44	14.3	
24	22.4	20.5	25.5	18.4				
26	24.0	21.8	27.2	19.8	47.5	1.50	16.0	
28	25.5	23.1	28.9	21.2				
30	27.1	24.3	30.7	22.7				

TABLE III—TURN AND APPLY PRESSURE—T AND AP

Weight	Time TMU for Degrees Turned 30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
Small — 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium — 2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large — 10.1 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.7	24.5	26.1	28.2

APPLY PRESSURE CASE 1—16.2 TMU. APPLY PRESSURE CASE 2—10.8 TMU

TABLE IV—GRASP—G

Case	Time TMU	DESCRIPTION
1A	2.0	**Pick Up Grasp** - Small, medium or large object by itself, easily grasped.
1B	3.5	Very small object or object lying close against a flat surface.
1C1	7.3	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter larger than ½".
1C2	8.7	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter ¼" to ½".
1C3	10.8	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter less than ¼".
2	5.6	**Regrasp.**
3	5.6	**Transfer Grasp.**
4A	7.3	Object jumbled with other objects so search and select occur. Larger than 1" x 1" x 1".
4B	9.1	Object jumbled with other objects so search and select occur. ¼" x ¼" x ⅛" to 1" x 1" x 1".
4C	12.9	Object jumbled with other objects so search and select occur. Smaller than ¼" x ¼" x ⅛".
5	0	Contact, sliding or hook grasp.

TABLE V—POSITION*—P

CLASS OF FIT		Symmetry	Easy To Handle	Difficult To Handle
1 - Loose	No pressure required.	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2 - Close	Light pressure required.	S	9.1	21.8
		SS	15.7	28.3
		NS	21.0	29.6
3 Exact	Heavy pressure required.	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4

*Distance moved to engage - 1" or less.

TABLE VI—RELEASE—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release

TABLE VII—DISENGAGE—D

CLASS OF FIT	Easy to Handle	Difficult to Handle
1 - Loose - Very slight effort. Hands not normally tight.	4.0	5.7
2 - Close - Normal effort. Slight recoil.	7.5	11.8
3 - Tight - Considerable effort. Hand re-coils markedly.	22.0	34.7

TABLE VIII—EYE TRAVEL TIME AND EYE FOCUS—ET AND EF

Eye Travel Time = $15.2 \frac{T}{D}$ TMU, with a maximum value of 20 TMU.
where T = the distance between points from and to which the eye travels.
D = the perpendicular distance from the eye to the line of travel T.

Eye Focus Time = 7.3 TMU.

. . . GATHERED THIS WAY . . .

for each specific part of a job can lead to the development of standard data as shown right. This permits establishing time standards or piece work rates before a style goes into production. Note how the MTM approach works. Each individual motion is identified by a description and the coded MTM symbol. For example, M4c is a four-inch move of an object to an exact location. This places the object at the attachment within a half-inch limit. The position which follows permits precise positioning of the material in the attachment.

METHODS ANALYSIS CHART

Dept. Sewing room Group Part No. B3EX
Operator's Name Clock No. Date
Observer's Name W.B.G. Work Place Singer mo. w/ruffler
Operation Sewing formula
Element Position 1st pc. in ruffler - no levers

	DESCRIPTION - LEFT HAND	CLASS	TMU	CLASS	DESCRIPTION - RIGHT HAND
1	Regrasp at new location (incl. w/ previous element)				Regrasp at new location
2			8.0	M4c	Move part into attachment
3			16.0	Plnsd	Position part in attachment
4	Regrasp for control	G2	5.6	G3	Transfer control to left
5			11.4	R16a	Reach to wheel of machine
6			2.0	G1a	Grasp hand wheel
7			6.9	M4b	Move hand wheel
8			2.0	RL1	Release hand wheel
9			6.1	R4a	Reach to new position
10			2.0	G1a	Grasp hand wheel
11	Total 68.9 TMU's		6.9	M4b	Move hand wheel
12	.0101 Hr./Doz.		2.0	RL1	Release wheel

. . . GIVES THIS RESULT

of a completed set of standard data for sewing operations. By carefully analyzing each operation, breaking it down into the convenient elements listed here, and doing detailed MTM studies for each element, these times were developed. Two classes of material were used—easy to handle and difficult to handle. These correspond to material received in neat piles from the cutters and previously sewn materials respectively. The rough, normal and close classifications specify the degree of accuracy required in the sewing, being within one-half inch, one-quarter inch and one-eighth inch respectively. Two cases of each element were used, to correspond with the normal locations of material — close beside the machine, or in the operator's lap. Size of material determined which location was used.

SEWING FORMULA

	ELEMENT DESCRIPTION		CLASS OF MATERIAL: EASY TO HANDLE Rough	Normal	Close	DIFFICULT TO HANDLE Rough	Normal	Close
	Pick up parts							
A1	Pick up part and put on table	to 12"	.0053			.0068		
A10	Pick up part and put on table	to 24"	.0066			.0074		
A2	Pick up 2 parts (2 hands) match on table to	12"		.0124	.0139		.0139	.0155
A20	Pick up 2 parts (2 hands) match on table to	24"		.0139	.0155		.0156	.0172
A3	Pick up 2 parts (2 hands) match in hand to	12"		.0108	.0124		.0142	.0158
A30	Pick up 2 parts (2 hands) match in hand to	24"		.0122	.0137		.0155	.0172
A4	Pick up 2 parts (2 @ time - 1 hand)	to 12"	.0053			.0068		
A40	Pick up 2 parts (2 @ time - 1 hand)	to 24"	.0066			.0074		
A5	Pick up part and match to part on table to	12"		.0097	.0103		.0105	.0121
A50	Pick up part and match to part on table to	24"		.0112	.0128		.0128	.0145
B1	Position under regular foot		.0009	.0033	.0049	.0009	.0033	.0049
B2	Position in hemming foot			.0044	.0060			
B3	Position 1st pc. in ruffler, no levers			.0101				
B3a	Position 1st pc. in ruffler, with levers			.0106				
B4	Position 2nd pc. in ruffler, no levers			.0095				
B4a	Position 2nd pc. in ruffler, with levers			.0100				
C1	Fold edge		.0036	.0060	.0076	.0044	.0069	.0085
C2	Fold edge (part in machine)		.0020	.0044		.0028	.0052	
C3	Fold strip with crease			.0110	.0141			
D1	Make pleat by hand - away from operator		.0023					
D2	Make pleat by hand - toward operator		.0017					
E1 3	Regrasp (pick up) at new location	to 3"	.0023			.0023		
E1 6	Regrasp (pick up) at new location	to 6"	.0027			.0027		
E2 3	Regrasp (sliding) at new location -match to	3"		.0050	.0066		.0050	.0066
E2 6	Regrasp (sliding) at new location -match to	6"		.0054	.0070		.0054	.0070
E3 3	Turn part to align with foot	to 3"	.0009			.0017		
E3 6	Turn part to align with foot	to 6"	.0015			.0023		

a week. Every group of motions involved was carefully analyzed and catalogued.

The sewing time portion of the operation presented no problem. A series of checks were made to find the actual RPM of the machines during the sewing cycle. By considering the number of stitches per inch and the RPM of the machine, the actual time required to sew any given distance was easily calculated. This was set up in the form of a table for easy use in establishing standards.

With the basic information gathered, the next step was to test the formula. Unless it produced accurate time standards, it would be of no value. So extensive checks were made, checking the formula's time standards against stop watch time studies.

Results were generally good, but there were some serious variations. A closer look was taken at all operations that varied more than 5% between the MTM standards and the time study standards.

The findings were surprising. Virtually every case of failure to meet the MTM standards was caused by poor methods being used by the operator. Once the operator was shown the proper way to do the job, she was able to meet and exceed the MTM standards.

Proper training for supervisors

This indicated two things. First, the operators weren't being trained in the proper methods. Second, the time study standards weren't as accurate as they had been considered.

The problem here was obviously to train the supervisors in the proper methods, and to make sure that they passed this information to the operators. Accordingly, a series of training classes were held, at which the supervisors were instructed in the proper methods to be used.

By using the MTM analyses on which the formula was based, the differences in method were pointed out, with emphasis being placed on the amount of time lost through not following correct methods. Examples of correct methods and poor methods being used were compared with MTM and actual costs calculated.

The supervisors were then reassigned to their departments to work with the operators in using correct methods. Production rose continuously for the following month, finally leveling off about 20% above the previous level.

There was a similar experience in the training of new operators. By having the supervisors concentrate on explaining correct methods. The inexperienced operators caught on quicker, and were able to meet the new standards much faster.

This demonstrates one of the potential pitfalls in using MTM. It requires a completely new approach to your problems. You can't just decide to use MTM and put it in overnight. Unless you are willing to take action to correct poor methods and revise layouts when indicated, MTM won't help you.

Facing up to your problems

But if you are willing to face up to your problems and take effective action, you can use MTM for virtually any problem where accurate knowledge of labor costs is important.

The sewing formula (shown earlier) was simplified because it was possible to standardize conditions. For example, the small size of most of the production made it possible to store the pieces being sewn in one of two places. Material was either on the table beside the machine, or on the operator's lap.

But the formula did have problems, too. The varying quality requirements presented a challenge. This resulted in the establishment of three categories of sewing.

Rough sewing involved items such as doll bodies where accuracy within one-half inch was acceptable. Normal

Here are some comments from users of MTM

MTM taught our engineers much about the manufacturing end of the business.—Sportswear manufacturer.

MTM works wherever there are sewing operations: shirts, suits, ladies' slips, pants, bras and shoes, too. In about three to five minutes we can tell designers just what their changes on garments will cost—much to their dismay, now and then.—Large U. S. needlework plant.

MTM seems designed especially for sewing operations . . . Nothing has revolutionized (the industry) so thoroughly as MTM.—Trouser and slack manufacturer.

Ninety-five percent of our packaging is now on MTM standards . . . MTM is a whole new trend in thinking as far as cost reduction is concerned.—Shirt manufacturer.

We have saved as much as 40% on seaming operations through MTM. MTM for a small organization manufacturing a number of products is an unusually efficient tool.—Lingerie manufacturer.

MTM has been applied to saving walking time, improving work place layouts and redesign of shipping department—Leather products manufacturer.

We have realized a 50% reduction in training time of newcomers to the sewing business. And, surprisingly enough, we save 20% training time on experienced operators placed on new jobs.—Women's suits manufacturer.

Here's how you can use MTM in your plant

Do it yourself

This is the approach that most smaller shops try. It has the advantage of being economical and you learn a lot through setting up your own system.

The key is the selection of the right man to get the training. You want someone who knows the operations of the shop, who is constantly alert to better methods and who has a genuine interest in learning about MTM. Some experience in time study often helps, but isn't essential.

Training in Canada is available only through licensed consultants. Courses must be approved by the MTM Association for Standards and Research. Normal length of the course is three weeks—and it's tough.

Don't expect miracles right away. A couple of week's intensive use of MTM in the plant after the course is a must before you tackle a big job, such as a formula.

Most consultants will recommend at least a one-week follow-up by one of their men in your plant a month or so after the end of the training. It is valuable insurance against getting off on the wrong foot.

Hire a consultant

If you want results fast, hiring a consultant can usually bring them. By picking a good consultant with experience in MTM and in your line of work you can avoid much of the breaking-in period you must expect when you bring in an outsider.

You can get a fresh viewpoint of your operations—and a training program designed to fit your needs. Larger firms tend to use this approach, because it permits setting up an in-plant training program in MTM where a number of employees can be trained simultaneously.

The biggest drawback to hiring consultants to produce standard data and formulas for your plant is usually a lack of follow-up. There is nothing like working on the development of such material for a thorough understanding of it. And without this understanding you may be in for plenty of trouble.

Of course, you may combine the best of the two choices by getting one or two men trained ahead of time in MTM courses, then letting them work with the consultant on the development of the material you need.

sewing moved the accuracy to one-quarter inch, while accurate sewing required positioning within an eighth of an inch. If necessary, these limits could have been progressively tightened to provide for even greater control.

Part of the improvement in production came about by mechanical improvements, new attachments, etc., that were suggested by MTM analysis. For example, an automatic cutting foot was installed on a chain-stitch machine. This eliminated a trimming operation.

New equipment is evaluated

In another case an automatic cutting foot wasn't practical, but the installation of a cutting knife at the rear of the machine permitted the operator to cut the thread with one simple motion instead of picking up a pair of scissors to cut the thread.

New equipment was evaluated by MTM. When a new machine was being considered, detailed analyses of the motion patterns of the existing and proposed equipment showed the possible savings. Accurate figures showed which equipment was economically justified.

Possibly the biggest single problem in any MTM application is to determine the best possible method. For example, in sewing operations an inexperienced operator might have to regrasp a part at a new location several times. An experienced operator could eliminate most, if not all, of these extra motions.

Careful observation and experiments soon eliminated most of these problems and indicated which methods an experienced operator could use.

One of the most common questions about the use of MTM and time formulas is the effect of materials on the time values. Consider this quotation from Dwight E. Wheeler, formerly Chief Industrial Engineer C. H. Masland and Sons, Carlisle, Pa.

Unfamiliarity with material

"The differences between the materials on which the operator works are not as important as they were originally considered to be. The biggest difficulty seems to be unfamiliarity with the material rather than the need for a changed motion pattern."

He said this to an international conference on the use of MTM. He was reporting on his company's experiences in switching from a 40-operator sportswear operation to a 600-operator program of government contracts involving fishing and hunting jackets and trousers, flying suits, tents, engine and wing covers and automobile deck and floor mats.

Materials used included duck, nylon, coated plastic, woven paper, carpet and wool. Machines ranged from Singer 241-13 and Union Special 61400 to the Singer 145W and Union Special Sampson. Yet MTM was able to provide accurate time standards over this wide range of operations and materials.

It can do the same for you.

MTM NATIONAL II

HISTORY DEVELOPMENT AND FUNDAMENTALS

By
R. J. Lawes
Massey Ferguson, Ltd.

Speech delivered at 9th Annual MTM Conference
June 1960—Toronto, Ontario

In our first look at Methods-Time-Measurement, so much more simply and universally known as "MTM", it is necessary to go back a few generations and look at industry in 1885 when a certain Mr. Frederick W. Taylor produced workable incentive payment schemes. I, myself, do find it a little difficult to believe that, in all the time that people have worked for other people for gain, there never was any incentive payment scheme previously.

Still, Mr. Taylor was the first recorded man to start thinking in the terms of what we now, rather glibly, call "scientific management," in fact he is often called the Father of Scientific Management. I have wondered, sometimes, if he would not have, maybe, looked down his nose at this possibly doubtful honor. I say this because sincerity is essential in human relations, and incentive pay is one form of harnessing human energy and a vicious harness will ruin any horse.

However, as you will realize later, after this gentle initiation, MTM does not necessarily mean incentive payment, there are other applications,—sincere, honest, clear thinking applies in every case. The point about sincerity was not intended as a digression, by any means, it was definitely part of Mr. Taylor's make-up, though it was the need for more and better production that triggered his fundamental contributions which have led, among other things, to the present pre-determined time standard systems.

He had noticed that there was no real effort to work, output was meagre and he, as the foreman, needed production or, obviously, Midvale Steel Company of Philadelphia would not need him. Thus he was merely observing one of the basic truths which governed his industrial life,—"Production is the foundation of material prosperity."

From his supervisory position he noted that the key lay in control of the method. It is a rather sad thought that we humans learn very little from history and that we do not change much. Much that applied in Mr. Taylor's time applies now, when I speak in the present tense, I may still be thinking about his time, but know that a particular comment remains true. So it can be understood that operators do not change much.

By this I mean that, since most operators are unskilled or semi-skilled, with all due respect to the quality of the work that they produce, and I refer to the average, honest operator, without leadership they will all see the job differently and will all dream up different methods accordingly.

Actually, it seems to be logical and true to say that, where there is a multiplicity of methods, the ideal method has not yet been found.

If one considers the common or garden black or graphite pencil for a moment,—the only way to make a readable mark with it is to rub the pointed end on writing material. There are different ways of holding the pencil, but the ideal way to write is still to rub the sharp end on the paper, in fact, that is the only way that I have ever found.

The same thought could be applied to the common or garden nail. The nail has a blunt end and a sharp end, the only way to get the nail into a softer material is to put that sharp end against the soft material and strike the blunt or head end.

Let us return to our very ordinary pencil,—we have decided that the ideal,—the only way, is to use the sharp end. This word "ideal" does not mean much to me, it is good as a trade-mark,

but I like to think that the best ideas that we have today will be improved tomorrow.

Thus, though the pencil makes its best mark with its sharp end, there are other methods of marking or writing, each offering, in its own way, the best possible for a given set of circumstances. The banker will not accept the common pencil, the pencil cannot be read by the blind, the normal fountain pen does not write on glass and so on.

Mr. Taylor decided that he must find the method appropriate to the need. He produced an instruction card for the operator and then he made his time studies. His rational production started to be real, he had evolved a principle which will holds good,—

> "The greatest production results when each worker is given a definite task to be performed in a definite time and in a definite manner."

That was a clear and simple statement, it was true then and is still true, just as true as it is to say that there are twelve inches to the foot.

Taylor never relaxed this insistence upon the importance of the method. I think he would smile in his sleep if he knew of the present-day number of his industrial descendants.

He had made a very great contribution to Industry and to the working man, he had fought a way through the fog of haphazard and wasteful industrial thinking.

We must remember, however, that he was dealing with heavy industry and, very probably, he could have studied many jobs with a sand-clock and a carpenter's foot-rule.

A few years later one Frank B. Gilbreth, started his own line of research into methods. He had become a successful building contractor but, all the time, he had had what one might call an extra-mural interest in the "atomic structure" of methods.

This had been sparked by his observation, on his first day as an apprentice, of the variety of methods used by bricklayers. It nagged away at the back of his mind so much that, eventually, he gave up his successful business and, in my opinion, but with all respect to Frederick Taylor, became the real father of modern scientific management.

Mr. Gilbreth's wife, Lillian, herself a trained psychologist, was a tower of strength at his side as they did the first-recorded basic research in micro-motion study.

We can now see the start of what I call the micrometer approach to work-measurement as compared with that earlier foot-rule approach of the first time-studies, even though that early work was such a vast improvement and, of course, a giant step in what we call the Industrial Evolution. Later, when I have explained more of the details, I will be able to show you why I think that there is this big difference.

The Gilbreths studied operators at all methods, they always sought the "one best way," they found that they must use the motion-picture camera, they photographed and studied and re-studied, even the term "micro-motion study" was a Gilbreth idea in 1912. Their definition can be read thus:

> "Micro-motion is the study of the fundamental elements or subdivisions of an operation by means of a moving picture camera and a timing device which indicates accurate time-intervals on the film itself."

(I would like to interject a comment on work-study at this point. This term was first brought into use in the United Kingdom by Mr. Russell Currie of Imperial Chemical Industries and was intended to cover or group all the techniques and procedures developed to increase productivity and reduce costs.)

To assist in this study the Gilbreths hit upon the technique which they called the "Chronocycle-graph." The operator had small flashing bulbs attached to hands (or to any other part of the body, depending upon the work which was being studied).

The bulbs are arranged to flash on quickly and to die away more slowly; the resulting film showed pear-shaped dots, rather like comets, which indicated the direction of the operator-motion, and would be used with a stereoscopic camera for the most effective interpretation of the results. This method still holds good, though not every company is equipped nor needs it, especially with the advent of MTM.

The Gilbreths did so much to dispel that methods-fog that I hesitate to estimate their influence on world industry.

The stress of World War I accelerated

application of standards. Possibly the one bright thought about wars is that methods and ideas often appear out of the stress. During quieter times, there is too much lethargy, people cannot be bothered. On the other hand, because of that very same stress so many so-called experts and charlatans jump in for easy pickings. Thus it spoiled things for the genuine practitioner,—you know how one drop of ink can discolor a big bowl of water. However, with the stimulated research spreading throughout the world there was material or significant progress and "labour" became much less suspicious and therefore much more receptive.

One must always remember that any waste of labour, effort, time, is a total loss (material generally can be recoverable, at least in part). Up to now, outside fiction, time has not been made reversible. Therefore, one can see that the two earlier schools, the Taylor-founded time-students and the Gilbreth micro-motionists had that essential common interest,—they were both striving for economical production, but it was not until about 1930 that they realized that they were really on the same team, whatever their other differences of opinion might be.

Without going into too much detail at this stage, the broad difference between time-and-method-study is that in time-study it is actually the man who is being studied and not the method as much. This difference will be more obvious to you by the time we have all finished.

My own first contact with motion-study was made about 1930 when I was an apprentice with Metropolitan-Vickers in Manchester and I saw Miss Anne Shaw at work. She was a person well-known in such circles in England. Miss Shaw seemed to specialize in the economy of motion, and I shall never forget the strange feeling I had the first time that I saw a girl trained to do two identical operations with each hand, quite simultaneously. She would pick up, for example, two screws, drop them into pilot holes, reach for and pick up two screw drivers hanging vertically on stands, they would be the Archimedian-spiral type where the handle is pumped up and down, and in a few strokes she had run the screws home and was reaching for the next-planned components. For people who have never seen ambidextrous motion patterns of this nature, it is quite a revelation, but, of course, such smooth flowing patterns are only achieved after much concentrated study and analysis prior to the final operator-training. . . .

As the last part of my apprenticeship I was moved into a drawing office on the development of equipment and work-place layouts designed from the method point of view. I was most fortunate in working for an engineer who left me to my own devices for days on end and thus I became a methods addict.

If one regards all these labour-time-measurement systems as being part of the industrial engineer's or the efficiency expert's tool-kit, it is then possible to see that a tool is always (or should be) selected according to the application in question.

Now there are cases where a simple time-study may be adequate, for a number of reasons:

a) a very long, tedious operation,
b) a job, which being non-standard, would seldom be repeated,
c) there would be no standard data available and answer would be needed as one of those "rush jobs, immediate or sooner,—the man has started,—and has only seven more to do. . !!!

In the main, a time-study is rather similar to a temperature chart at the foot of a hospital bed. This chart shows a morning and an evening thermometer reading; to make these independent points easier to see and to read, each consecutive pair is joined by a straight line, but there is absolutely no means of knowing what happened in between, (when trying to interpret the temperature), without having been present all the time.

In the older time-study it was not customary, nor was it possible with some of the watches used, to note down the fine elemental divisions that are now quite usual. I will go so far as to say that a person trained on the micro-motion or on the predetermined time standard systems would make a more detailed and, therefore, more accurate, time-study, even without much time-study experience.

If I may return to my apprenticeship for a brief moment again, I shall always remember the "rate-fixer" as he was called. He rejoiced in the name of Shufflebottom and we apprentices swore that, judged by the studies he put across us, he would make a cork-screw look like a straight-edge. The studies were corase, there were no sketches of work-place layouts, of parts, no mention of difficulties, no one ever mentioned "off-standard conditions," there was no guarantee of any bonus opportunity, just a mysterious ten per cent "contingency" allowance.

Frankly, I have to admit that I made little bonus, I was generally too busy making gadgets, fixtures, and tools to make the operation easier. Then I would be in hot water,—later I would be told how much more efficient or productive the next fellow was . . . but he was using my despised improvements!!!

As you get this methods-bug into your blood, and it does not matter if you are making a study or analysis of a complicated weldment, of a girl packing a shirt, a letter being folded and sealed in an envelope or unfolded and put into a filing cabinet or of Betty Crocker making apple fritters, you begin to look for the PATTERN.

For an everyday example consider your own garage at home. Let us assume that the floor is new and that you will always run your car in the same way round. After a while the floor begins to show marks, engine oil, grease spots, tyre tread marks, that lubricator which always leaks, you can almost sketch the shape of your car.

Then again, if you take a pair of dice or two pairs and throw them five hundred times, recording the details of each throw, you will begin to see a definite pattern in the score, the greater the number of throws recorded, the clearer the pattern, if you plot these totals on squared paper what is called a "bell-curve" will appear. The layout is simple, on the horizontal base are all possible totals and above each one as it appears you make a mark. (See Fig. 1)

In these two examples the patterns stem from two different sources: on the one hand, the repetition of a normal situation and on the other, a pattern which is statistically predictable.

It is on such statistical bases that predetermined time standards are built. The one and only way to gain a long experience is to let a lot of time pass by usefully and, in the same way, the only way to obtain standards and so produce data which can be as universal and as reliable as a slide rule requires vast numbers of observations.

Now the groping in a work-measurement fog is passed, the semi-private trail-blazing is over and an inviting highway starts to appear.

In 1934 Dr. H. B. Maynard founded the Methods Engineering Council and, from the beginning, one of the points on which he and his staff put great emphasis was training, believing that "show-how" was just as important as "know-

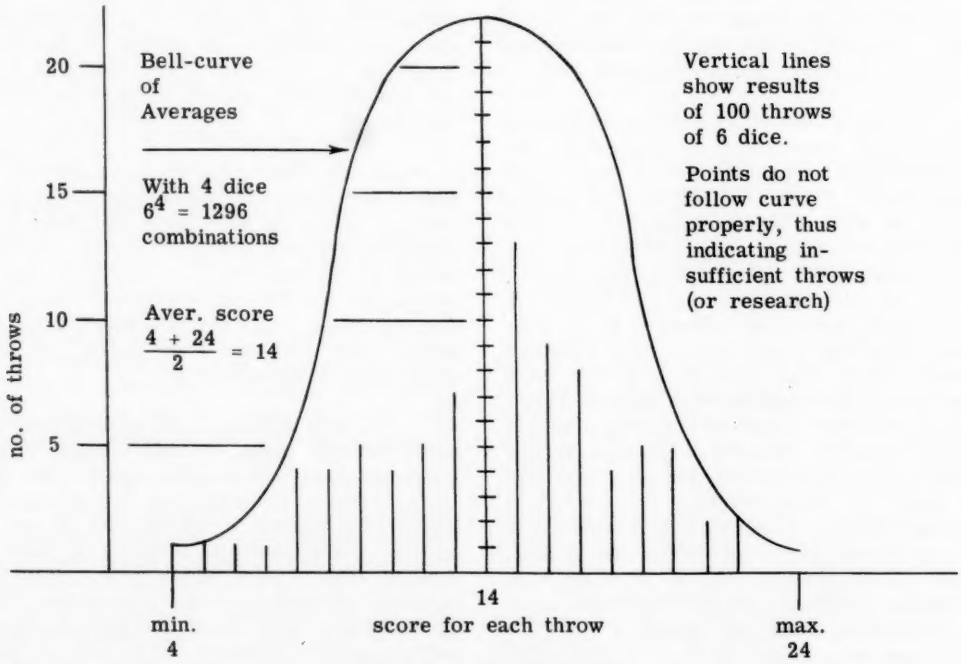


Fig. 1. Results of throwing dice

how." From this they observed that many cost reductions were the result of methods correction rather than the result of true methods work.

It was soon apparent that industrial illnesses were not being cured, they were being given palliatives, rather like trying to cure a dislocated wrist with a whiff of chloroform,—efficiency was built on to inefficiency, which brought little success.

From this there came the obvious conclusion that good methods should be established in advance of the production and from this a further conclusion that some form of standard data must be developed, that "methods formulae" must be produced in advance of the actual production for the best efficiency.

So was born the term "Methods Engineering" with its rather lengthy definition. I will read through it once, one could not ask you to memorize it for it is too long for comfort and, after all, we are much more interested in defining MTM. However, this definition does have a lot of "meat" in it and gives you a word picture of the thoroughness with which the competent practitioner must think and work. The quotation is taken from a book "Operation Analysis" by Maynard and Stegemerten and it runs:

> "Methods engineering is the technique that subjects each operation of a given piece of work to close analysis, in order to eliminate every unnecessary operation and in order to approach the quickest and best method of performing each operation; it includes the standardization of equipment, methods and working conditions; it trains the operator to follow the standard method; when all this has been done, and not before, it determines, by accurate measurement, the number of standard hours in which an operator working, with standard performance, can do the job; finally, it usually, although not necessarily, devises a plan for compensating labour which encourages the operator to attain or to surpass standard performance."

The term "engineering" is used in its broadest sense of creating something and is not confined to the manipulation of a piece of iron; "standard hours" is the time to complete one hundred cycles of a given task or operation.

This led to research, which in the beginning was confined to manual motions associated with operating a drill press, until it was realized that the motions could apply to any kind of manual work employing the same type of movements under similar conditions, in other words, basic data had been developed at long last!

The researchers followed the tradition of the Gilbreths and decided to film everything, with supporting notes and final test data of their findings under actual production conditions. Their main difference from the earlier workers was their firm belief that there was a basic connection between time and motion.

In evaluating basic research information every last detail has to be recorded, nothing is too small to be forgotten or ignored, nothing must be allowed to upset a true evaluation of a given situation or condition. Mathematically, one never makes an approximation in the middle of the solution of a problem; in a mental arithmetic rough check, one may make all the short-cuts desired but not where ultimate accuracy is required.

I would repeat that this great care belongs to the development stage, as in the construction of a slide rule, so that the later application will be smooth and reliable and the accuracy will depend largely on the skill of the practitioner. If one takes a first-class hunting or target rifle, zeroed-in and with the correct ammunition, clamps it in a vice and shoots ten rounds, the weapon will give the maximum accuracy because there is no human interference. The only way to get better shooting will be with better rifles or better ammunition. Now if the weapon had a worn barrel, if the ammunition was patchy in its loading, then there could be no guarantee of accuracy, no matter how good the man behind the sights. There is one other point to this, one that you will understand better later on, the inexperienced man with that beautiful rifle is probably going to make a worse showing than the old hunter using his worn-out but familiar gun. In the same way, the mere possession of this first-class MTM data card does not make you immediately into a first-class industrial rifleman, but, with its help, proper training, and your own ability you will soon be able to shoot away ahead of that poor, but honest hunter. . . .

Scientifically speaking, in the derivation of any measurement it cannot be indicated correctly by a single figure but by all the values between two limits. These limits are dependent upon the delicacy of the equipment, the uniformity of the conditions during all observations and the competence of the research worker.

Cameras are available with stepped speed-

settings from 500 to 4000 frames per minute and, of course, there are ultra-high speed cameras which expose up to 10,000 frames per second. These will yield a vast number of frames, each requiring the same meticulous examination for an above-reproach accuracy.

Since the field of work measurement is almost limitless, it is difficult to formulate aims and ideals on which to base an all-embracing technique, it is just as dangerous to over-elaborate as it is to over-simplify.

In any application the approach must be professional, in the best sense of the word, one might almost say "clinical." The person dealing in such systems is very often in a rather aloof position, something between man and management.

Any system is rather a combination of mathematics and human engineering welded together by a little human understanding and psychology. Such work measurement deals with people so there is no point in underlining the need for fairness and caution.

All work done must be substantiated by clear, concise and legible paperwork, so clear that six months later anybody, including the originator, can see why or how a certain conclusion was reached and so on.

From this it follows that any system must be clear and simple, not that one needs to have a master's degree in mathematics, with several years as an insurance actuary, to follow or apply it. Systems that are too complicated will choke themselves to death.

The ab initio training should not be very long, provided the right type of person has been selected, (there are always square pegs which appeared to be round when selected, in the beginning), this happens in every walk of life. One very, very important factor in the proper training, and one which reduces the basic training value, I would say, by seventy per cent when it is omitted, is the in-plant or on-the-job application follow-up; I do not think that I need elaborate on that.

Any system should have a certain built-in flexibility so that continuing research, which is part of progress, will continue to substantiate present data and show improvements to meet changing conditions.

A good system will lend itself to application, more or less universally. One that offers immediate or obvious restriction in application will have only limited value. Naturally, if one works along particular lines, with possibly oft-recurring features or elements, then one adopts short-cuts or even standard data within standard data, but this is always fulled documented.

Among the systems of which you may have heard mention there is the first and oldest: "Method-Time Analysis" (MTA), devised by a Mr. A. B. Segur. It has stood the test of time but until recently, that is until about 1956, was veiled in secrecy. "Work Factor" is another system with what one might call limited-disclosure. It has several sets of data according to the "roughness" of the answer required.

General Electric has several private systems, "Get and Place," "Motion Time Standards" (MTS), and a fairly recent one "Dimensional Motion Times" (DMT). The first is a sort of estimating procedure, MTS is somewhat similar to Work Factor with its different scales of application, while DMT is based on grouping standardized operations according to some dimension relationships. These again are only semi-disclosed, the data would have applications slanted in the G.E. direction because G.E. is known for its employee-training schemes, and, though there was no public dissemination of the information, neither was there any oath of secrecy.

In Canada there is the brain-child of the Woods Gordon Company known as "Basic Motion Time Study," a system which has been published fairly fully. It is based on MTM with variations which are intended to improve or ease the application, it is not really a separate system basically, but I have no documentation to support any comparison.

I hope that by now I have given you sufficient historical notes on the growth of work measurement and work study so that we can now move on to the basics or fundamentals of MTM.

Thus we see that there is not one highway, there is a network, some paths are narrow, twisting, meandering, there are others that start out like turnpikes and fade out in a wilderness. Others give uniformly average driving conditions and so on.

The official definition of MTM has remained unchanged since its origination. I find this an interesting though silent testimonial to its simple completeness.

It is concise enough to be memorized quite easily and reads:

"Methods-time measurement is a procedure which analyzes any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the condition under which it is made."

In breaking down any motion into its basic parts Frank Gilbreth made a list of seventeen such parts and to avoid a cumbersome title, such as "motion element" of "hand motion" he reversed his own name and called them "Therbligs," a name which has stuck because, despite its sounding like a visitor from outer space, it is practical.

He devised written and pictorial symbols, colour schemes, even said what pencil from which company would give the correct colour. This was all very good, but in my opinion, a little elaborate and, with about one person in seven having some aberration in their colour-sensing, would render such colour signals liable to misinterpretation.

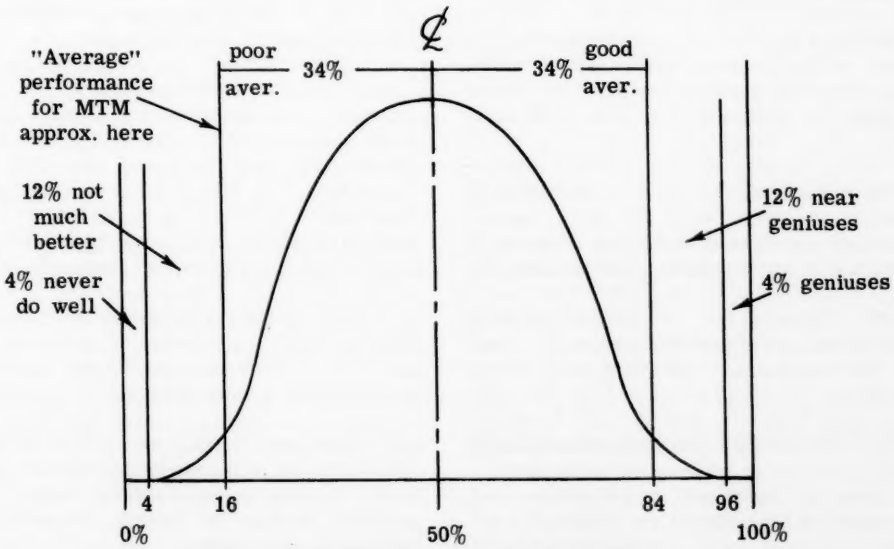
I do not intend listing the Therbligs because we are much more interested in the shorter and more practical list for MTM users. There are a few other terms which we use and which should be defined now because they may otherwise confuse:

"Effort" is the will to work, the enthusiasm which an operator puts into the task at hand. It should NOT be confused with the similar term in dynamics involving foot-pounds.

"Skill" is the proficiency in performing a particular task or operation, the "slickness" that the operator develops while doing that one task, for example, a road sweeper may be classed as far more skilled than the finest surgeon when it comes to handling a broom.

Both of these terms have their grades from poor to good in six steps and this applies also to "conditions" which have, likewise, six classes from poor to ideal.

"Levelling" or "Levelled time": these refer to performance. As you can see from the varying factors of effort, skill, and condition there will be greatly differing results if only time-studies are used without reference to these factors. It is thus necessary to indulge



Bell-curve related to people and performance

Fig. 2.

in that very tricky business known as "performance rating" about which books have been written, score cards developed and reels of practice film published. I mention this complication in such terms because in MTM all time values have been levelled before they are printed on the one and only true Data Card. After the myriads of examples were analyzed it was possible to find a very just average, one that would give ample opportunity for a man to earn bonus under an incentive scheme, fair pay for fair work. (See Fig. 2) The Mr. Segur to whom I referred previously said in 1927, "Within practical limits, the time required for all experts to perform true fundamental motions is constant" and this can indicate that as people become skilled at any one task, even different people; the overall time should be very similar because it will be based on the minimum number of motions which therefore must be fundamental.

The fundamental definitions are for Reach, Move, Turn, Crank, Apply Pressure, Grasp, Release, Position, Disengage, Eye Motions, Body, Leg and Foot Motions, and Motion Combinations. Each is defined as follows:

REACH - Table I SYMBOL R
Reach is the basic hand or finger motion employed when the predominant purpose is to move the hand or fingers to a destination.

MOVE - Table II SYMBOL M
Move is the basic hand or finger motion employed when the predominant purpose is to transport an object to a destination.

TURN - Table III SYMBOL T
Turn is the basic motion employed to rotate the hand about the long axis of the forearm.

APPLY PRESSURE - Table III SYMBOL AP
Apply pressure is an application of muscular force to overcome object resistance, accompanied by little or no motion.

GRASP - Table IV SYMBOL G
Grasp is the basic finger or hand element employed to secure control of an object.

POSITION - Table V SYMBOL P
Position is the basic finger or hand element employed to align, orient and engage one object with another to attain a specific relationship.

RELEASE - Table VI SYMBOL RL
Release is the basic finger or hand motion employed to relinquish control of an object.

DISENGAGE - Table VII SYMBOL D
Disengage is the basic hand or finger element employed to separate one object from another where there is a sudden ending of resistance.

EYE TRAVEL - Table VIII SYMBOL ET
Eye Travel is the basic eye motion employed to shift the axis of vision from one location to another.

EYE FOCUS - Table VIII SYMBOL EF
Eye Focus is the basic visual and mental element of looking at an object long enough to determine a readily distinguishable characteristic.

BODY, LEG, AND FOOT MOTIONS - I will not define this, they are fairly obvious when you hear the names: Sit, Stand, Sidestep, Turn Body, Bend, Stoop and Arise, Kneel and Arise, Leg Motion, Foot Motion, and Walking.

As a matter of interest Walking standards are based on 3.57 m.p.h.

I want to underline one or two points. For example, the hyphenated "Methods-Time" is so written to show that there is a positive connection between the two parts and that they are really inseparable. It is important to note that the word "methods" precedes the word "time" because the method must, I repeat, must be established before a true value time can be assigned.

As we all know the word "manual," from its Latin root, relates to the hands but its meaning here is widened to cover all body motions in predetermined time systems.

The unit of time used in MTM is called a TMU, that is a Time-Measurement-Unit, and is fixed as being a one-hundred-thousandth part of an hour, that is in figures, decimal zero-zero zero-zero one hours. This is not as frightening as it sounds because there are approximately twenty-eight to the second. As any photographer will tell you it is risking a good picture to hold a camera without support for an exposure of one twenty-fifth of a second and one TMU is only a little shorter.

The average human eye cannot detect a time interval of less than one tenth of a second so it certainly will be beaten by the smaller TMU. If you drive at 60 m.p.h. you travel at 88 ft. per sec. which equals about three feet per TMU. From this you can see that it is a very small division of time in relation to any average human body motion.

As far as one can say, the values ascribed to various body motions are correct within the limits of any known industrial methods involving the body motions of the average or normal operator.

In a world which is harnessed so much to centesimal counting systems (not to mention dollars by name) there are distinct advantages in this little TMU. If the total elapsed time is written down as so many TMU, then putting the decimal point three places from the right gives the time per hundred cycles. This standard hour value when multiplied by an hourly rate in dollars gives the labour cost, with one important reservation.

No man should be expected, in these enlightened times, to work on solidly, without any break at all. I am ruling out situations of peril and emergency where the motivation is supranormal or supernormal. For normal working conditions in any field, there must be fatigue and personal allowances, otherwise all the accurate work has been for naught, we are always dealing in these matters with human beings. Such necessary allowances should be added, percentage-wise, to any allowed operation times, to give the final standard hour value. Each company must take care of its own overhead accounting in any suitable manner.

When making any analysis there are several different approaches that may be adopted in considering any operation or situation. These are: by observing any given operator; by visualizing whilst seated in some remote corner; by a combination of these two or by what is called "Data Synthesis." This combines the first two with any mathematical or graphical techniques and/or other legitimate means which one may have up one's "technical sleeve," and I use the word "technical" in its broadest sense. Predetermined time standards are not the property nor the sole prerogative of the engineering side of life, progress belongs to everybody!

As everyone must agree, this covers a tremendous field, but by its very nature, is something which can be used, like bricks, as has been indicated all along, to build any reasonable combination of body motions into an operation. The information is all on three sides of this very, very compact Data Card and in addition there is a table which shows what motions can or cannot be performed simultaneously with other motions. With this card and a tape measure you can face the world, if you are a qualified practitioner which, of course, should be your next objective. I say "if" because if you are not skilled in its use you can cause more harm than good. This warning is printed on the front of every data card. The mere possession of a driver's license does not make anyone a good driver, there must be training.

The training, though intensive, is not difficult. It is applied common sense, is common sense in any language, and is used in so many countries nowadays, even in Japanese I understand that they use the letters MTM without translation.

Without being too repetitious I would like to repeat that the development, the re-awakening, the new slant on even everyday movements will be a revelation to you. If you have chosen MTM then you are riding along one of the best "work-measurement turn-pikes" yet devised!

If you run an office, just cast your mind's eye over the scene—who uses the filing cabinets most? Is it the highest paid persons in the office? Do they have the farthest to walk? Why??? When you walk into your office do you put your bag down on your desk, walk back to the coat rack, then back to your desk. . . ? Have you ever made a rough layout of your office (perhaps with carbon copies), and then traced in the work-and-walk patterns of the various people???

Have you ever designed a fixture? If so, did the operator need a wrench to tighten a hex. head bolt? How much time did he lose every time he looked for the wrench? Did the bolt head wear until the wrench slipped and you had an accident report??? Could you not have made that bolt with a bar welded on cleanly to make a handgrip??? Is this not all a matter of simple applied common sense????

All those little points have, what I call, invisible costs, any money you waste is a free gift for your competitor, it's a misguided charity, you give him a false sense of security, he leans back, takes things easily, neither of you can meet nor beat rising costs!!! then a foreign government subsidizes dumping here, and we have chaos!!! You cannot afford to miss this training!!!!

MTM NATIONAL III

Rear Admiral Frederick L. Hetter

U. S. NAVY DEPOT WAREHOUSING

Rear Admiral Frederick L. Hetter

A great surge forward toward the complete automated warehousing of 245,000 items stored at the Bayonne, N.J. Naval Supply Center will be made in November when a 1,200 foot conveyor fitted with electronic accessories starts operating.

Because of tremendous initial costs and the financial risks of a sudden switch to complete automation, the change at Bayonne, a two-mile long peninsula in the heart of New York Harbor, will be accomplished in phases, the conveyor being the second in a series.

The new operation is the forerunner of general conversion to automated warehousing throughout the Naval supply system. Other giant supply centers will probably follow Bayonne's lead. It is the start of a tremendous improvement in effective supply support of the fleet and other Navy activities.

The Navy's essay into this field is the first instance of automated warehousing on a large-scale multiple-product basis; there being a few civilian firms that operate with a few single product items.

Bayonne's first step was the repositioning of material according to its speed of turn over. Installation of the conveyor to dovetail with popularity storage is the second step that will eventually lead to electronic data processing machines triggering a completely automatic system including mechanical stock pickers.

Many ships of the fleet already order supplies by means of electronic punch card machines. The Navy hopes to eventually feed these cards directly to the data processing machines ashore and wait for the material to come out at the other end like gum-balls from penny machines.

Fabrication and installation of the initial portion of the unit at Bayonne will be performed by the Rapids Standard Company of Grand Rapids, Michigan. The award was for $349,000.

Rear Admiral Frederick L. Hetter, SC, USN, commanding officer of the Center, who has supported the development almost since the idea first came up five years ago, said that its installation can be justified on two main grounds: 1. Increased production efficiency and 2. Economy.

> "It is anticipated that the output among the 245,000 items handled by the conveyor will eventually reach 60 percent," Admiral Hetter said. "We also hope to have the installation amortize itself in better than five years."

Admiral Hetter points out that a general survey of the large installation was made before any decision was arrived at in respect to the conveyor.

> "Our convictions about costs were confirmed when it was shown that the greatest expense in transportation here is incurred inside the buildings where supplies are moved by hand trucks, fork lifts, and tractors.
>
> "This pointed to the conveyor as the means of the greatest savings."

First step in fitting the Center for automation was accomplished gradually. Repositioning stock in the order of its turnover was integrated with the existing system as an improvement in it.

Although there are 24 large buildings and considerable outdoor space concerned with stocking the 300,000 items handled by the Center, 90 day quantities of the 245,000 affected items were stored on the second floor of the main seven-story buildings. Bulk quantities of them were stored on the upper floors for the purpose of fast replacement.

Items too large or heavy for efficient or effective inclusion in the system are kept outdoors or in other buildings.

The conveyor will run the length of the main building bisecting long rows of bins, so positioned that the most popular items are closest to it on both sides.

Warehouseman stationed at the heads of the bins put the called-for items in special tote-boxes on the sides of which they set signals that will be acted on in the packing section.

When the conveyor reaches the end of this building it will pass over an enclosed, already existing bridge, to the packing and preservation building directly behind.

It will run to a large section that for all practical purposes will be laid out on the principles of a railroad marshalling yard.

When the tote-box with its signal reaches a special electronically operated sensing machine, the signals sent with it by the warehouseman will automatically shunt it to an appropriate unit. Also in this area will be a man at an electronic console.

The console, by a system of lights, will give the operator an exact picture of what is going on in this area; and he, by pushing a button, will be able to correct any inequality of workload or take advantage of changing conditions that would step-up production.

Areas in this section are: 1. Overpack; 2. Parcel Post; 3. Manufacturer's Package Line; 4. Freight-rate Breakdown; and 5. Customer Accumulators.

The purpose of these areas is to package the parcels properly and send them on their way in the fastest and most economical manner.

Within the Overpack Area, parcels are packaged according to whether they are for delivery in the Continental United States, overseas or within the Metropolitan Area. This section also can also be used as a pressure release when the workload in the other sections gets too great. The man at the console can divert work from over-loaded packers to those in this section.

A considerable amount of supplies go out by Parcel Post and hence a special section set aside for it; also, many items come to the Center adequately packaged by the manufacturer. Men in the Manufacturer's Package Line need only block out the original address and substitute the address of the item's new destination.

Freight rates for various types of material are higher than for the more gross items. Therefore, at the Freight-rate breakdown point, items are separated according to their nature so that first-class rates will not be paid on third-rate supplies.

The Customer Accumulators are special areas used to gather many items destined for the same address. As they come along on the conveyor they are shunted aside to these areas until the whole order is present. They are packaged and sent on their way at the proper freight rate or by the most economical and efficient means of transportation.

> "We feel that we are approaching automation in the warehouse field at the fastest rate still consistent with good business practices," said Admiral Hetter. "Our conveyor, as it will be installed at the end of this year, is not a gamble. It will work, and it will pay for itself reasonably soon."

This system with the backing and encouragement of Rear Admiral James W. Boundy, SC,

USN, chief of the Bureau of Supplies and Accounts, was studied and developed by Center personnel assisted by engineers of the US Naval Supply Research and Development Facility which is at the installation.

When it is in operation different skills will be required than are now employed in the sections covered by the conveyor. However, provisions for this are being made in advance. Admiral Hetter stated that no one will be forced out of the gate because of automation.

Employment rolls are being designed to take advantage of retirements, resignations and other avenues of normal attrition to the end that employes affected by the new system will fare well. People being hired must have special skills or experience that will enable them to blend with the improved warehousing system.

Also, a program for self improvement through special educational classes is available to all employes.

"If nothing else is added the conveyor will be a success," said Admiral Hetter adding that "two other chunks are being studied for future automation.

"The first area is that between the printed documents and the picker; the second being between the packer and the shippers. We believe that we have attacked the area where we can achieve the greatest savings; and that those other areas, while we know that they can produce savings, may well be less responsive to automation.

"Very definitely, we know full well that items of large bulk and those that move infrequently and without pattern, are poor subjects for automation.

"We know that our system will work; and work well."

• • • • •

MTM BOOK REVIEW

MTM APPLICATIONS: MEASUREMENT FOR OPERATIONAL USE

By

Claude Catelas

Paris: Les Editions d'Organisation, 1960

Introduced by H. B. MAYNARD
President, Methods Engineering Council

Preface by P. Langlois
President, Technical Commission of the
French MTM Association

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MTM is a method for the analysis of human work, used most particularly for the elaboration of rational operational methods and for the calculation of international average time values.[1] The aggregate of elementary values for fundamental motions is directly utilizable in organized form without making it necessary to let "decisions of haste" intervene—an important advantage in comparison with stop-watch timing. At all times the selection of MTM motions should be made by specialists thoroughly qualified in time-study, knowing perfectly the details of the operations of their industry in order to define in MTM notation certain STABILIZED JOBS which the average executive as well as the specialist might recognize without too much "hesitation, reflection, or error." In other words, if MTM results are correctly established they cannot be suitable for anyone but the operator ACCUSTOMED TO HIS JOB. This difficulty in application of method is felt more specially by industries where mass-production is more limited and shifts in the manufacture more frequent.

The principal object of the book "MTM Applications: Measurement for Operational Use" is to present an unpublished method of correcting MTM standards in an objective manner, in function of the experience of the operators and to calculate average durations for USE and RE-USE. The formulas are based on recent experiments on certain groups of controlled motions, as well as semi-controlled and kinesthetic ones.

Measurement for operational use is, on the other hand, a new MTM application which offers efficient means of research for study of the problems of JUDGING ACTIVITY, of APPRENTICESHIP, of MOTION CAPACITY, of the SELECTION of OPERATOR TESTS, of MOTION PROGNOSIS, of PROFESSIONAL QUALIFICATIONS: a principal indication based on the degree of required control.

But this work is, in the very first place, a PRACTICAL MANUAL OF (INDUSTRIAL) ORGANIZATION. The numerous illustrations permit the reader only slightly familiar with the method to appreciate in it its technical interest. Moreover, the following question, of interest to all (production technicians?) are equally studied:

- SPEED of MTM CALCULATIONS = disc for the calculation of time and of use; synthesis of MTM stenography, of universal formulas for motions such as PICKING UP and LAYING DOWN, of MTM of the second degree.
- STUDY of the SYNCHRONIZATION of the PRODUCTION UNIT: study of the product with reference to the distribution of labor.
- STUDY of the PLACE OF WORK: SYNTHESIS of SDT with MTM. Presentation of detailed solutions.

This publication is intended, above all, for methods executives and for responsible production personnel.

• • • • •

1. Methods of Time-Study by H. B. Maynard, Stegemerten & Schwab.

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MARCH 1961

"Scientific Management and its Responsibility for Bettering the Standard of Living of the Americas," is the theme of the third Inter-American Management Conference, to be held from March 2 to 12, 1961, in Mexico City. The Confederación Patronal de la Republica Mexicana, the Mexican affiliate of the Pan American Council of the Comité International de l'Organisation Scientifique (PACCIOS) will organize the conference, which, in addition to papers on such subjects as "The Latin American Common Market as a Solution to Economic Development," "Practical Applications of Business Research," and "New Techniques in Business Administration," will include visits to local factories and informal meetings with Mexican industrialists.

Further information on the conference may be obtained from Colonel Philip Garey, Vice President of Operations, Council for International Progress in Management, 247 Park Avenue, New York City 17. The Council is organizing the United States delegation to the conference.

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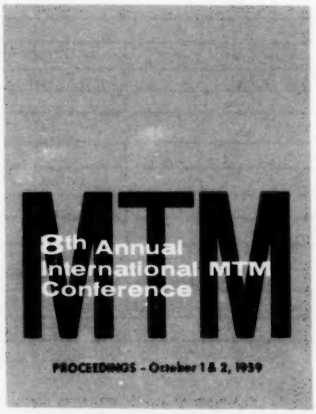

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RESEARCH REPORTS

R.R. 101 Disengage

This report contains a preliminary study of the element disengage. While it is still classified as tentative, the report contains some extremely interesting conclusions on the nature and theory of this element.

R.R. 102 Reading Operations

The first step in the use of MTM for establishing reading time standards is contained in this report. In addition, the report contains a synopsis of the work done in this field by 11 leading authorities.

R.R. 104 MTM Analysis of Performance Rating Systems

A talk presented at the SAM-ASME Time and Motion Study Conference, April 1952. It contains an analysis of performance rating systems and various performance Rating Films from an MTM standpoint.

R.R. 105 Simultaneous Motions

This report represents almost two man-year's work on a study of Simultaneous Motions. It is a final report of the Simultaneous Motions project undertaken by the MTM Association. While it does not purport to provide complete and exhaustive answers to all problems in the field of Simultaneous Motions, it presents a great deal of new and valuable information which should be of interest to every MTM practitioner.

R.R. 106 Short Reaches and Moves

This report contains an analysis of the characteristics of Reaches and Moves at very short distances. It develops important conclusions concerning the application of MTM to operations involving these short distance elements.

R.R. 107 A Research Methods Manual

The research activity of the Association has developed an effective and comprehensive set of methods for carrying on research in human motions. This report details the major techniques used. Adequate sources of motion data, film analysis, data recording, and statistical methods of analysis are among the topics discussed.

R.R. 108 A Study of Arm Movements Involving Weight

In this report, the results of a large investigation into the effect of weight on the performance times of arm movements are presented. While more effective means of determining correct time allowances for moving weights are given, the comprehensive discussion of the whole area of weight phenomena is probably of more fundamental importance. The effect of such conditions of performance as the use of one or two hands, sliding vs. spatial movements, and male and female performance are among the topics presented.

R.R. 109 A Study of Positioning Movements

I. The General Characteristics. II. Appendix.
This report, the first of two position reports, defines "positioning movements and the interrelation of component movements." The study is limited to the laboratory analysis, and contains an appendix dealing with several subjects outside the major objectives.

R.R. 110 A Study of Positioning Movements

III. Application to Industrial Work Measurement.
This report, the second on position, relates the results of the position research to the field of application. This study deals with actual industrial operators and work measurement tools, and the evolution of an improved and more efficient technique for controlling and improving manual activity through better understanding of positioning movements.